6. *The Microanalytical Laboratory*

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Objective: To develop methods for monitoring and characterizing microchannels and microfluid flow.

Problem: The concept of the microanalytical laboratory continued to grow rapidly in the last year with more than one new product on the market and many more on the way that integrate microfluid components. The majority of new products are being fabricated in quartz substrates since much of the necessary research has been conducted in this material allowing for a shorter laboratory-to-market time. There is much less known about plastic materials in terms of fabrication and micro-channel characterization. In the first year of our competence effort, we have focused on understanding and characterizing flow and surface chemistry in plastic channels fabricated by NIST imprinting methods.

Approach: The process used to fabricate plastic microfluid devices can influence the surface charge on the microchannel wall as has been demonstrated for laser ablated channels. The surface charge and charge density on the channel wall are critical issues in microfluidics since both the rate and direction of electro-osmotic flow are a function of wall charge. Wall charge also controls the adsorption of chemical and biochemical species. We have previously characterized the surface change associated with our plastic microchannel devices by monitoring the electro-osmotic bulk flow using the current monitoring technique. This method has been used to successfully evaluate flow in plastic microchannels. However, it provides no direct information on the location and density of surface charge in fluid channels. In the past year, we have developed methods to probe the surface of imprinted channels with fluorescent chemical labels that enable the identification of specific chemical groups. We refer to this process as chemical mapping. With chemical mapping, we can determine the effect of our imprinting procedure on the channel charge and can alter our fabrication protocols to modulate this charge. Another drawback associated with the current monitoring technique is that flow measurement is not performed continuously. Because of this limitation, the current monitoring technique cannot be used to detect changes in flow during the course of an experiment that may be caused by analyte adsorption or fluctuation in the source pump rate. To address this problem, we have been developing methods for integrating silicon elements for flow monitoring and control within our plastic microfluid devices.

Results and Future Plans: Labeling of imprinted PMMA micro-channels with group-specific fluorescent probes indicated that mechanical stress induced the formation of carboxylate moieties that were concentrated in the channel walls and in surface defects. Non-imprinted materials and the channel floors did not reveal significant amounts of carboxylate or amine functional groups. Proteins were preferentially adsorbed to the negatively charged channel walls as compared to the floor as shown in the figure. The formation of carboxyate functionalities in the PMMA using the imprinting techniques will likely alter the adsorptive and electrto-omotic properties of the polymer microchannels. Integration of silicon components with plastic microfluid channels for flow monitoring has also been a focus of our research. Microheating elements fabricated in silicon have been successfully coupled to polymer channels. Preliminary results show that these devices can be used to continuously monitor fluid flow in integrated microfluid devices. Future work will focus on chemically modifying the microchannel walls to alter channel charge for fluid control for flow stability. We will also attempt to implement microheaters in microfluid systems for flow control with feedback.

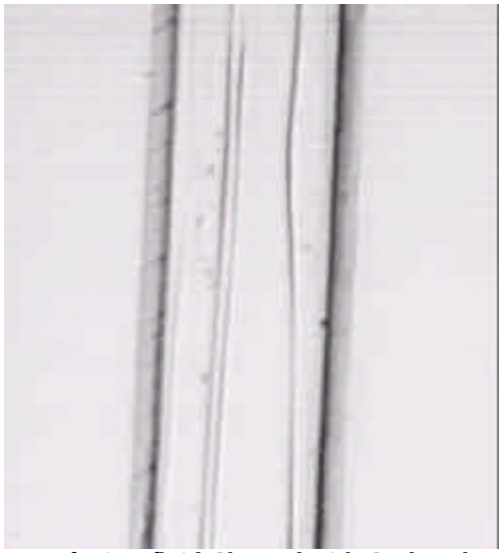

Image of Microfluid Channel with Carboxylate-specific probes.